LEVEL II

NONAUDITORY EFFECTS OF HIGH INTENSITY NOISE ON GROUND CREWS AT A NAVAL AIR STATION

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SUMMARY

Concerns about possible noise-induced, nonauditory effects in personnel working in and around noise suppressors at a Naval air station were expressed in a report by the Clinical Investigation Center of the Navy Regional Medical Center, San Diego. A specific request was made to look in detail at acute physiological and behavioral changes that might be attributed to high intensity noise levels.

In response to this request, a field study of the physiological, behavioral and subjective effects of intense noise among ground crew at Miramar was undertaken. Experimental group subjects were members of the Final Inspection Team on the runway or were working at one of the maintenance facilities in which static ground testing was carried out. All subjects were exposed to intense noise (above 110 dB) for various periods of time as part of their routine work schedule. Noise regulation standards (BUMEDINST 6260.6B) were observed with respect to total time of exposure for given intensities and the use of ear protective devices. A control group of age-matched enlisted personnel working at other "normal" noise level jobs on the base were also run.

Brain stem auditory evoked potentials, eye tracking, whole body balance, and optokinetic nystagmus tests of vestibular and vestibulo-ocular function were carried out on 14 experimental and 14 control subjects.

In addition, subjective mood and perception of illness, as measured with the profile of mood scale and Wahler Physical Symptoms Inventory, respectively, were obtained.

Eye-tracking data and balance platform data were reduced with the time series analysis methods of cross-correlograms and Fourier analysis. The reduced data, in terms of spectra of body sway and of lag and amplitude of eye-tracking ability showed no difference between groups that could be attributed to the intense noise environment.

The brain stem evoked potential, which measures the integrity of the auditory sensory channel from the primary receptors to the cortex also showed no group differences. Optokinetic nystagmus, recently reported to be ineffective even in distinguishing vestibular pathology, was only evaluated in a cursory manner and was not viewed as a variable that could add anything of substance to the general conclusions.

Subjective mood and perceived illness were likewise sufficiently similar in the two groups to rule out any real effect attributable to intense noise.

The conclusion of this study is that Naval ground crew in jobs for which BUMEDINST 6260.6B applies are not showing hypothesized nonauditory effects of intense noise, and that within the confines of the variables studied, no evidence exists that current safety measures and standards are inadequate.

INTRODUCTION

Review of both civilian and military research efforts attests to the Navy's long and productive program in hearing conservation. However, there has been relatively little effort in determining the nonauditory effects of intense noise, especially on personnel working in situations for which BUMEDINST 6260.6B, regarding noise exposure limits, applies. This directive was intended to conserve hearing and presumably does so. The effects on nonauditory systems associated with vestibular or ocular function is not addressed, however, and represents an area of considerable concern.

In response to a request from the Naval Ocean Systems Center (NOSC), Neff (1977) measured auditory and nonauditory effects of high intensity noise on ground crew in and around jet engines undergoing tests in a noise suppressor (Hush House, NAS Miramar). The study resulted in a list of safety requirements and suggestions for possible safety devices and alluded to possible extensive noise-related health hazards. Although hearing thresholds and temporary threshold shifts were of primary concern, other hazards, implicating at least temporary dysfunction of other sensory and motor systems were noted. In particular, vestibular and oculomotor function, as measured by an electronystagmograph during and after exposure to noise led to the conclusion that such functions were "abnormal". It was implied that disequilibrium, dizziness, blurring of vision and other effects occurred and, as such, represented a "highly dangerous" situation. The far-reaching consequences of such exposure for nonauditory physiological systems is completely unknown.

A "noise questionnaire" was reported to have been administered, but since no data was included and results were not quantified, it is not possible to evaluate the subjective and behavioral aspects of high intensity noise effects. The interpretation given by the author was that some workers "(1) had difficulty in visualizing an instrument panel, and (2) experienced instability during and dizziness after exposure to high intensity jet engine noise." Other "impressions" were that some workers had "difficulty concentrating," felt "irritated" and experienced "impairment of fine motor coordination," and were concerned about "keeping balance". Although of some use in designing a research study, these impressions cannot be used to draw conclusions about the effects of high intensity noise on physiological, behavioral or subjective response.

Within the range of frequencies around jet engines during testing, there are noise intensity levels sufficient to cause concern for health. Goldman (1957) and von Gierke (1961) discussed the effects of high intensity noise that sets off resonances within the body cavities. Certain frequencies stimulate touch, pressure and joint movement receptors that may lead to fatigue, nausea and disorientation. The significance of body resonance lies in the fact that the mechanical amplification of vibration in body systems is correlated with the physiological response. The response is frequency-dependent. The effects of vibration on the sensitive vestibular mechanisms which operate through fluid movement in closed systems is possibly the basis for these effects, although the upper limit for this is unknown (Gillies, 1965). In addition, nystagmus and other visual effects have been reported. Anticaglia (1970) found that brief exposure to noise (1) modifies color vision, (2) diminishes night vision, (3) adversely affects depth perception, (4) provokes mydriasis, and (5) influences intraocular pressure. Long exposure seemed to have a permanent effect on narrowing of the visual field.

With respect to the pathology associated with high noise exposure, recent work has led to some understanding of the mechanisms involved. For example, the organ of Corti has been shown to degenerate in response to high intensity noise. The mechanism is fairly well understood. Oxygen consumption by the primary receptor cells is not a self-limiting process. When the available oxygen is not sufficient for the continued function of the receptor cells, they degenerate. In the guinea pig, 120 dB noise causes vasoconstriction in the spiral vessels of the basal membrane serving the cochlea. There is a concurrent decrease in oxygen tension in the endolymph which is thought to reflect an increase in the rate of oxygen utilization by the cochlea. Eventually utilization out-strips supply, resulting in hypoxia and consequent hair cell dysfunction and degeneration. As these vascular lesions progress, hearing thresholds increase. The threshold shift is temporary if these changes are reversible. However, continued overstimulation results in irreversible lesions of cell degeneration and a permanent threshold shift.

Recent work by Cazals et al. (1980) showed that the brain stem auditory evoked response (BAER) and cortical evoked potential both continue to appear, in modified form, after total destruction of the hair cells of the organ of Corti. The modified brain stem responses resemble the evoked potentials of the vestibular nuclei, and it therefore appears that the vestibular system may be responding to sound. Both evolutionary and electrophysiological evidence are cited by Cazal as support for this inference.

If one considers the continuity of the fluid medium of the organ of Corti and the vestibular canals, a similar degeneration of primary receptor cells might be expected in the utriculus, sacculus, and crista ampularis of the vestibular apparatus in response to intense vibration. In this case it is not sound vibration conducted through the outer and middle ear that is important, but rather bone-conducted low frequency vibration that results from standing near wide-band high amplitude noise sources. If such degeneration is in fact occurring, it might appear at multiple levels in physiological systems:

1. The degeneration of hair cells in the organ of Corti, in the utriculus and sacculus, and in crista ampularis in each of the 3 semicircular canals.
2. Changes in the transmission characteristics of the sensory nuclei associated with hearing and balance. The integrity of the major auditory nuclei is measurable with the BAER. The neurophysiological overlap of auditory and vestibular pathways suggests that vestibular system degeneration might also appear as a change in characteristics of BAER latencies.

On the basis of these considerations and preliminary discussion with Mr. Meyer Lepor, Project Manager, Jet Engine Ground Run-Up Noise Suppression Project, NOSC, it was proposed that a controlled study be undertaken immediately of the physiological, behavioral and subjective effects of high intensity noise. The study was designed and implemented according to the standard principles of research methodology, i.e., manipulation of noise as an independent variable and measurement of several dependent variables associated with the systems and behaviors of interest.

Although the extent to which noise invades animal tissue and the degree of absorption at various frequencies is documented for the human body (e.g., Gillies, 1965), the effect of this impact, in the form of vestibular dysfunction in humans, is not known. The present study concentrated on those physiological systems and behavioral measures implicated in previous Navy work, namely the vestibular sensory system, the oculomotor system, and sensory-motor integration systems. In addition, the measurement of brain stem auditory evoked responses (BAERs) were used to assess possible damage within the neuroanatomically defined auditory pathway.

METHODS

Subjects

For this study, subjects consisted of 14 individuals (13 men, 1 woman) who were exposed to high intensity noise as part of their daily work routine ("noise" group) and 14 age-matched controls who worked at other places on the airbase at which there were no unusual sound levels. The mean age for the two groups was 23 years. All subjects signed an approved consent form prior to partaking in the study.

Subjective Data

Four kinds of subjective data were collected during the initial test phase. First, pilots and ground personnel were interviewed during the course of the study to identify the major components of activity around the final inspection point (FIP). One purpose was to determine the approximate amount of time spent by individuals within the various isointensity noise boundaries depicted in Figure 1. The reports were generally consistent in stating the FIP personnel could be anywhere from 50 to 150 feet off the tail of the aircraft during take-off. Engines were either at military power or afterburner power. Sometimes final inspection team (FIT) members would remain on the runway in the

SOUND LEVELS IN dBA

This table contains estimated sound levels in dBA for TF30-P412A and F401-PW400 afterburning turbofan engines. Sound level contour letters A, B, C, and D (shown on this illustration) represent a specific dBA value. When dBA value is located on this table, it shall be substituted in place of contour letter.

CONTOUR	MAXIMUM AFTERBURNER POWER		MILITARY POWER	
	TF30-P412A	F401-PW400	TF30-P412A	F401-PW400
A	134 dBA	138 dBA	123 dBA	129 dBA
B	130 dBA	134 dBA	119 dBA	126 dBA
C	127 dBA	131 dBA	116 dBA	122 dBA
D	123 dBA	127 dBA	112 dBA	118 dBA

NOTE

Sound level contours shown are for single engine operation. Contours are symmetrical about engine centerlines during dual engine operation.

Figure 1

Isointensity contours of exhaust noise intensity at Final Inspection point

interim between take-off procedures. Although the precise amount of noise exposure per individual cannot be quantified because of the variability in procedures and type of aircraft, the general noise level for most take-off procedures was in the range from 120 dB to 138 dB. It was the general opinion of both pilots and experienced ground crew that a greater noise itensity occurs in the region of the catapults on aircraft carriers.

The second block of data consisted of a brief interview. The questions posed and a summary of responses for the noise group is given in Table 1.

Table 1

Interview Questions and Responses

1. How long have you worked around jet aircraft?
2. How long have you worked on this job?
3. Anything unusual about your hearing, vision or balance?
4. When was the last time you were exposed to intense noise?
5. Anything unusual about your sleep?

	Responses				
Subject	1	2	3	4	5
1	8 yrs	1 yr	"ringing"	continuous	no
2	2 yrs	13 yrs	"hearing loss"	-	no
3	13 yrs	7 mos	"visual focusing"	2 yrs	no
4	19 yrs	8 mos	"bad hearing"	this A.M.	no
5	2 yrs	14 mos	no	frequently	no
6	2.5 yrs	approx. 2 yrs	no	-	-
7	3 yrs	3 mos	"near sighted"	30 min	no
8	1 yr	3 mos	"hearing"	8 mos	no
9	8 yrs	1 yr	no	1 wk	no
10	10 yrs	1.5 yr	no	60 min	"sleep more"
11	3 yrs	3 yrs	no	30 min	no
12	5 yrs	3 yrs	"yes"	5 min	no
13	2 yrs	2 mos	no	this A.M.	-

Following the interview, the Wahler Physical Symptoms Inventory (1973) was given. The 42 items of the test are arranged on a Likert scale and are based on parts of the MMPI, parts of the Cornell Medical Index, and input from practicing clinicians. Test time was approximately 10 minutes.

The Profile of Mood Scale (POMS) was then given. This 62-item test results in 6 dimensions of subjective mood. Test administration time was approximately 12 minutes.

Instrumentation

For the purposes of this study, a special test van was borrowed from the Navy Personnel Research and Development Center. The van had been constructed for the purpose of collecting various kinds of test data in the field and was found to be ideal for the present purpose. The inner dimensions were approximately 9 feet by 20 feet and consisted of adjustable partitions and tables so that several areas for specific purposes could be defined.

The instrumentation developed for the various tests in the present study is described below:

1. Brain Stem Auditory Evoked Response (BAER) Recording System.

A Nicolet Model 1072 signal averager with associated components was used to compute and display the BAERs. A wide range sweep control Model #SW-71B, in conjunction with a signal digitizer Model #SD-72/4A, provided a means for accumulating the 2024 click-evoked responses that constitute each BAER. The dwell time on the sweep control was set at 40 μsec, and the filter on the signal digitizer was set at .04 msec. The click stimulus was generated by a Grass Model S4 stimulator set at a frequency of 10 Hz, with a .01 msec delay and a duration of .1 msec. The voltage on the stimulator was adjusted for each subject such that the click presented at the earphones was 60 dB above threshold. This adjustment was accomplished with a HP attenuator Model #3750A in a series with the output of the stimulator. EEG from the vertex (Cz, 10-20 International Electrode System) referenced to the contralateral ear was amplified by a Grass Model P511J. The rise time was set at .1 msec (or 1/2 amp high frequency cut-off of 3K Hz). The corresponding low frequency cut-off was 100 Hz. Amplification was set at 500K. Accumulated BAERs, each consisting of the average of 2000 responses, were recorded on a Hewlett Packard Model 7034A X-Y recorder. Calibration of the instruments was such that the 10 msec BAER extended the horizontal distance of the screen and the X-Y plotter surface. The amplitude was calibrated such that 10 microvolts equaled approximately the height of the screen and height of the X-Y plotter surface.

2. Eye Tracking Task.

A sinusoidally moving white disk was generated with an oscilloscope and signal generator. The X-input of a Tektronix Model 214 oscilloscope was connected to the output of a Wavetek sine wave generator. The beam on the scope face provided tne disk image. The connection of the X input of the oscilloscope provided a horizontally moving target. A corresponding vertically moving target was generated by connecting the Wavetek to the Y input of the oscilloscope. A video camera was placed directly in front of the face of the oscilloscope and connected to the input of a JVC Model 3600 video cassette recorder. Video cassettes of the experimental session, consisting of different frequencies and directions of movements of the disk were then prepared. These cassettes were then used as the stimulus to obtain eye tracking data. During the recording session, the output of the video cassette recorder was connected to the input of a video monitor located on a nearby table. A chin rest was attached to the same table at 46 cm from the face of the video monitor. The top of the chin rest was padded with foam rubber and was fixed at 25 cm from the top of the table. The chin rest was adjusted such that an average-sized person could sit in a chair in front of the chin rest for several minutes without discomfort. Data were stored in analog form on a Philips Minilog 4 cassette recorder.

3. Balance Task.

A statometer, borrowed from the U.S. Navy Experimental Diving Unit, Washington Navy Yard, consists of a metal plate suspended from a rigid metal frame by four strain-gauge bolts. The output of the gauges comprises the legs of two Wheatstone bridges such that the output of the bridges reflects changes in force along the lateral and sagittal axes. A vertical component is not available. The analog voltages in the X and Y dimension were amplified by Tektronix amplifiers and recorded on 2 channels of the Philips recorder for subsequent data reduction.

4. Optokinetic Nystagmus Task.

A series of white bars were placed vertically on a black cylinder attached to an electric motor. By turning the cylinder at various speeds, a nystagmus generating stimulus was provided. The image of the moving bar on a dark background was adjusted with respect to a video cassette camera and recorder such that a constant velocity moving bar target traversed the video monitor screen at varying sweep rates determined by the speed of rotation of the cylinder. After determining the sweep rates to be used in the task, the stimulus was recorded on video cassettes to be used during the actual data recording sessions. The output of the cassette recorder was connected to the input of a TV monitor as for the eye tracking task. The subject sat at the edge of the table and placed his chin in the chin rest described above for the eye tracking task. A photo voltage cell, located at the center of the screen, monitored the movement of the bar and was recorded on one channel of the tape recorder. Eye movements were recorded with the same eye movement recording system used for the eye tracking test.

PROCEDURE

Upon entering the test van, each subject was asked to read and sign the consent form. The procedure was then explained and the interview questions were administered verbally. Responses were recorded in a log book. The Wahler Physical Symptoms Inventory and the Profile of Mood Scale were then administered. Electrodes for the BAER, eye tracking, and nystagmus test were attached while the test forms were being filled out.

For the BAER, a Grass electrode with Grass electrode paste was attached to the scalp at the vertex. Two additional Beckman biopotential electrodes were attached at the mastoids. The vertex served as the active source and was referenced to the contralateral mastoid. The ipsilateral mastoid electrode served as ground. Electrode resistance was measured after application and was kept at less than 5K ohms for all recording sessions. Subjects were instructed to sit in a reclining chair and were tilted back so that the head approached a supine position. The earphones were then placed on the head. Calibration of the auditory "click" stimulus was accomplished by setting the attenuator at 60 dB and then varying the voltage on the stimulator until the click for a given ear was "just audible". The attenuator was then set to zero so that a click of 60 dB above threshold was generated. Subject was instructed to close his eyes and relax as much as possible while the clicks were presented. When the BAER for the right ear was complete, it was stored in memory on the Nicolet and a similar procedure was carried out on the left ear. When both BAERs were complete, the digitized record was recorded on the X-Y recorder. A cursor was then moved through the visual display to the 7 positive peaks of the BAER. Amplitude and latency of each prominent peak were written on the ink record for later analysis.

Upon completion of the BAER recording procedure, the eye tracking task was administered. Biopotential electrodes were attached to the outer canthus of each eye and amplified by Tektronics amplifiers. Conjugate eye movements during the test were stored on one channel of the Philips recorder. The output of the video cassette visual display was simultaneously recorded on a second channel of the recorder.

The task consisted of instructing the subject to rest his chin on the chin rest and to assume a comfortable position. He was then told to focus his attention on the center of the white disk that was about to appear, and to follow it as closely as possible. The video cassette was then played. The target moved back and forth in the horizontal direction for 30 sec each at .1 Hz, .2 Hz .3 Hz, and .5 Hz. The angle of eye movement was 30 degrees per cycle. At the end of the task the subject was instructed to relax until the next task. Tapes of recorded eye movements and target movements were labeled and stored for later analysis.

Subjects were then instructed to stand within two footprints on the horizontal surface of the statometer. Part 1 consisted of 2 minutes with eyes focused on a black disk located approximately at eye level and approximately 4 feet from the platform. Part 2 consisted of standing for 2 minutes on the platform with eyes closed. Analog data from the X and Y dimensions of the platform were stored on two channels of the Philips recorder. At the end of the task the subject was instructed to sit at the table until the next task. Labeled data tapes were then stored for later analysis.

The optokinetic nystagmus task consisted of instructing the subject to rest his chin on the chin rest and to follow the movements of the white bar as closely as possible. The video cassette was then played, displaying the bar stimulus for three 30-second sessions. The sweep rates for each session were .6 per second, 1.5 per second, and 2.1 per second, respectively. When the task was completed the subject was disconnected from the electrode box and electrodes were removed. Nystagmus data on analog tapes was then stored for later analysis.

RESULTS

The results are presented as comparisons between the experimental group (intense noise environment) and the control group (normal noise environment).

Subjective Variables

The individual interviews were conducted during the period immediately following the orientation. The data are summarized in Table I. These data serve to indicate that current job-related noise exposure was perceived as high, that a fairly long history of noise exposure was reported, that approximately 50% felt they had some sensory disorder, and that no unusual sleep problems occurred.

The Wahler Physical Symptoms Inventory (WPSI) and the Profile of Mood Scale (POMS) were administered to each subject.

Table II

Wahler Physical Symptoms Inventory (WPSI)

The WPSI was administered to all subjects. This test, which was derived from the Cornell Medical Index, the MMPI, and from practicing clinicians, provides a standardized, quantitative measure of the degree to which clients stress physical complaints. The WPSI score is based exclusively on somatic complaints without an admixture of psychological symptoms. A comparison of group mean WPSI scores showed no significant difference between the noise-exposed group (E) and the control group (C), thus indicating that the exposure to high noise did not lead to excessive somatic complaints.

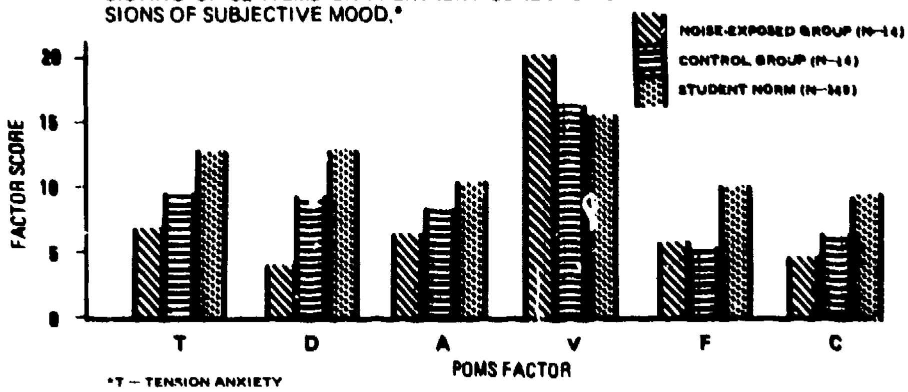
ITEM ANALYSIS

	E		C			E		C	
Item	M	SD	M	SD		M	SD	M	SD
1.	.64	.74	1.07	1.27	22.	0	0	0	0
2.	1.79	1.31	2.36	1.74	23.	1.5	2.31	.71	1.38
3.	1.93	1.77	.73	1.39	24.	.71	1.26	.43	.85
4.	1.21	1.42	1.21	1.81	25.	.21	.58	.79	1.12
5.	.57	1.16	1.14	1.29	26.	2.14	1.83	1.93	1.69
6.	1.71	1.82	1.50	1.65	27.	.14	.36	.71	1.44
7.	.93	1.54	.71	1.20	28.	.29	.83	.21	.58
8.	.36	1.34	.07	.27	29.	.57	1.40	1.21	1.61
9.	.43	.94	.71	1.54	30.	0	0	0	0
10.	1.29	1.77	1.36	1.69	31.	.93	1.44	.50	.85
11.	.57	1.50	.31	.63	32.	1.14	1.23	.86	1.17
12.	1.36	1.45	2.36	2.10	33.	.07	.27	.36	.63
13.	.57	.76	1.07	1.49	34.	.86	1.35	.71	1.20
14.	.14	.53	0	0	35.	.36	1.34	.14	.36
15.	0	0	.07	.27	36.	0	0	.07	.27
16.	.79	1.31	.43	.76	37.	.79	1.67	.43	1.09
17.	.07	.27	.07	.27	38.	.50	1.40	.43	.94
18.	.93	1.44	.36	1.34	39.	.50	1.34	.71	1.44
19.	0	0	.14	.36	40.	.21	.43	.50	.85
20.	.14	.53	.14	.36	41.	.50	1.29	.50	.85
21.	0	0	0	0	42.	.29	1.07	.86	1.35
			Composite Score:			.62	.47	.65	.44
								t = .45 NS	

TABLE III

PROFILE OF MOOD SCALE (POMS)

THE POMS WAS ADMINISTERED TO ALL SUBJECTS. THIS SCALE, CONSISTING OF 62 ITEMS ON A LIKKERT SCALE IS SCORED ON 6 DIMENSIONS OF SUBJECTIVE MOOD.*



*T – TENSION ANXIETY
D – DEPRESSION-DEJECTION
A – ANGER-HOSTILITY
V – VIGOR
F – FATIGUE
C – CONFUSION-BEWILDERMENT

		T	D	A	V	F	C
NOISE-EXPOSED GROUP	$\bar{X}$	7.7	3.9	7.1	19.5	5.6	4.5
	S	4.4	4.5	7.9	4.2	5.3	2.8
MATCHED CONTROL GROUP	$\bar{X}$	9.1	8.9	7.6	17.1	5.1	5.9
	S	5.2	3.1	8.1	5.4	3.8	5.0
STUDENT NORM	$\bar{X}$	12.9	13.1	10.1	15.6	10.4	10.2
	S	6.8	10.5	7.8	6.0	6.2	5.2

The mean and standard deviation for each of the 42 items of the WPSI are listed in Table II. The composite scores, which are the group means for the experimental and control groups do not differ (t = .45, NS). It was of some interest to compare individual items on this test that appear to be relevant in terms of symptomatology that might be expected to appear in an intense noise environment. The items were selected a priori so that a test of a subsample of items could be made. The items selected for individual testing were #2 headaches, #3 trouble with ears or hearing, #7 shakiness, #23 trouble with eyes or vision, #28 dizzy spells, and #41 chest pains. Item #2 (headaches) is not further considered because the difference is in the wrong direction. There was no difference between groups for #41 (chest pains). Items #3, 7, 23, and 28, which refer to ear trouble, shakiness, eye trouble or dizziness, show differences in the hypothesized direction, but are not significant by Student's t-test. We therefore concluded that personnel working in this type of intense noise environment do not perceive themselves as having more than the usual somatic complaints.

On the POMS a very high level of vigor was reported by the experimental group, but reference to the summary analysis of variance for these data shows that the differences were not significant. The other 5 scales also showed no significant difference between the experimental and control groups, or between these groups and the test's student norms.

It is concluded that subjective mood, as measured by the POMS, is not significantly affected by the intense noise conditions present in the experimental groups work environment.

Physiological Variables

BAER: An example of a normal BAER is given in Figure 2. A cursor was moved consecutively to each of the 7 peaks and values of latency and amplitude recorded at the correspondoing points on the hard copy. Only latency measurements

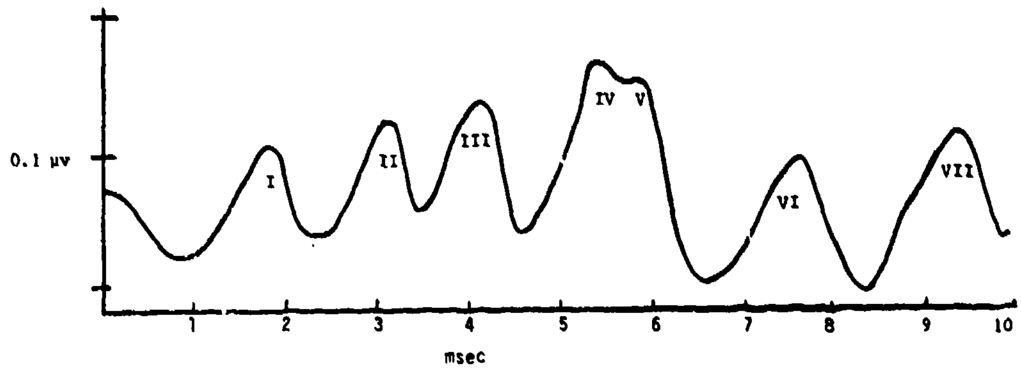


Fig. 2 Idealized BAER, showing the seven major positive components. Active lead is at C_z.

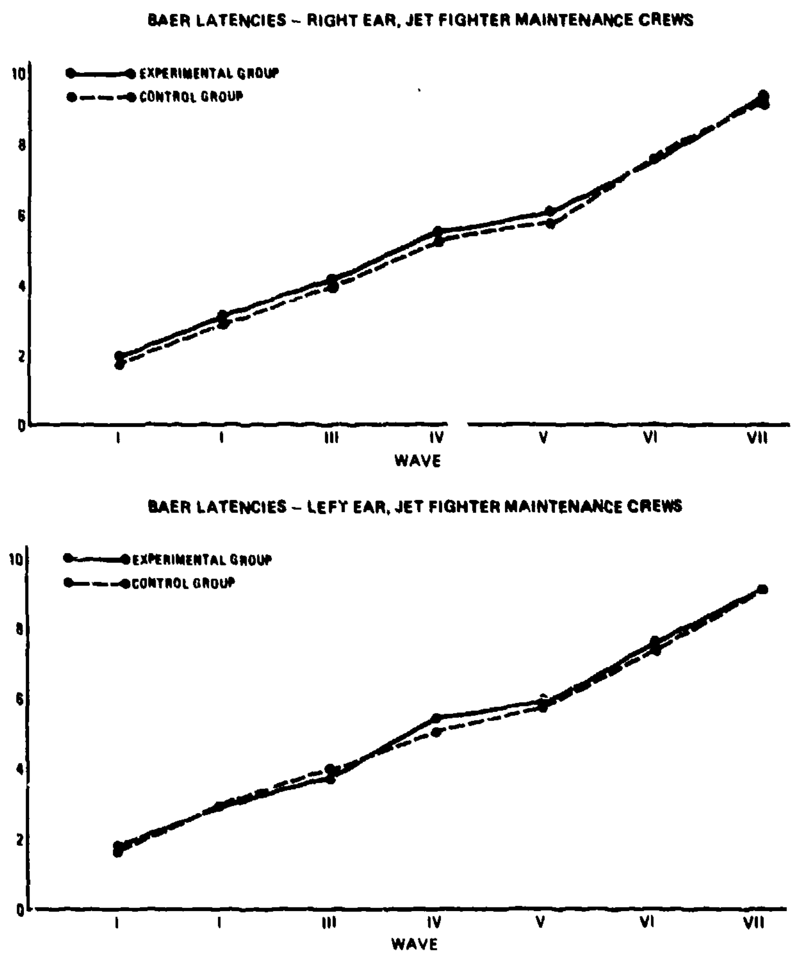


Fig. 3 Latencies of the seven major peaks for the right and left ear.

were included for tests of differences between groups. The results are shown in Figure 3 and Table IV, which is a repeated measures ANOVA for the 7 positive peak latencies. As indicated, these latency measures were not different between groups.

Table IV

ANOVA for BAER

Latencies

	Left Ear		Right Ear	
Fg	= 0	p NS	= 0	p NS
Fc	= 42.5	p <.01	= 51.1	p<.01
Fgxc	= 1.7	p NS	= .8	p NS

g=Control vs. Experimental group dF = 1

c=Components of the BAER dF = 5

gxc = Interaction df = 5

Eye Tracking: The eye-tracking data was stored simultaneously on two channels of the tape recorder during the test periods. One channel represented the analog movement of the visual target and the other channel was of the corresponding EOG. Cross correlograms were then obtained for each of the 4 sweep rates at .1, .2, .3 and .5 Hz for each subject. The variables of interest from the cross correlograms include the phase angle, which is a measure of the degree of lead of lag of eye movements relative to target movements, and amplitude, which is a measure of the degree of "regularity" in the eye-tracking behavior. If the eye movements are in near perfect synchronization with the target, the cross-correlation amplitude will be high. If the frequency of eye movements varies widely around some mean value, even if that mean value is equal to the target's frequency, the cross-correlation amplitude will be low. The summary results of this analysis are given in Table V.

Table V

Summary of Hotelling T Square Analysis of Phase and

Amplitude of Eye-tracking Correlograms

Frequency

	1	2	3	4	5	6	7	8	9	10
Hotelling T Square	3.53	2.29	4.16	5.28	2.98	2.51	1.41	0.73	3.73	0.23
p Value	0.25	0.36	0.17	0.11	0.27	0.33	0.52	0.71	0.20	0.90

As the data in the table indicate, the group mean phase and amplitudes are not different by use of Hotelling's T^2 for any of the integer frequencies from 1 to 10. It is therefore concluded that eye tracking, under the conditions of this study, is not significantly affected in personnel working in high intensity noise environments.

Balance: The output of the balance platform is an oscillating signal that is approximately sinusoidal. A Fast Fourier Transform was therefore applied to the anlog signal as the first level of data reduction. This resulted in a spectrum of movement intensity (in arbitrary units) as a function of frequency. One spectrum was generated for each experimental condition in each subject. For each subject there was one spectrum each for the forwards-backwards direction and the left-right direction, and for both eyes open and eyes closed conditions. These individual spectra were then averaged across subjects within each group to yield 4 mean spectra for each group. The mean group spectra are given in Figure 4. It can be seen that the general form of these spectra is similar in that the maximal intensity occurs

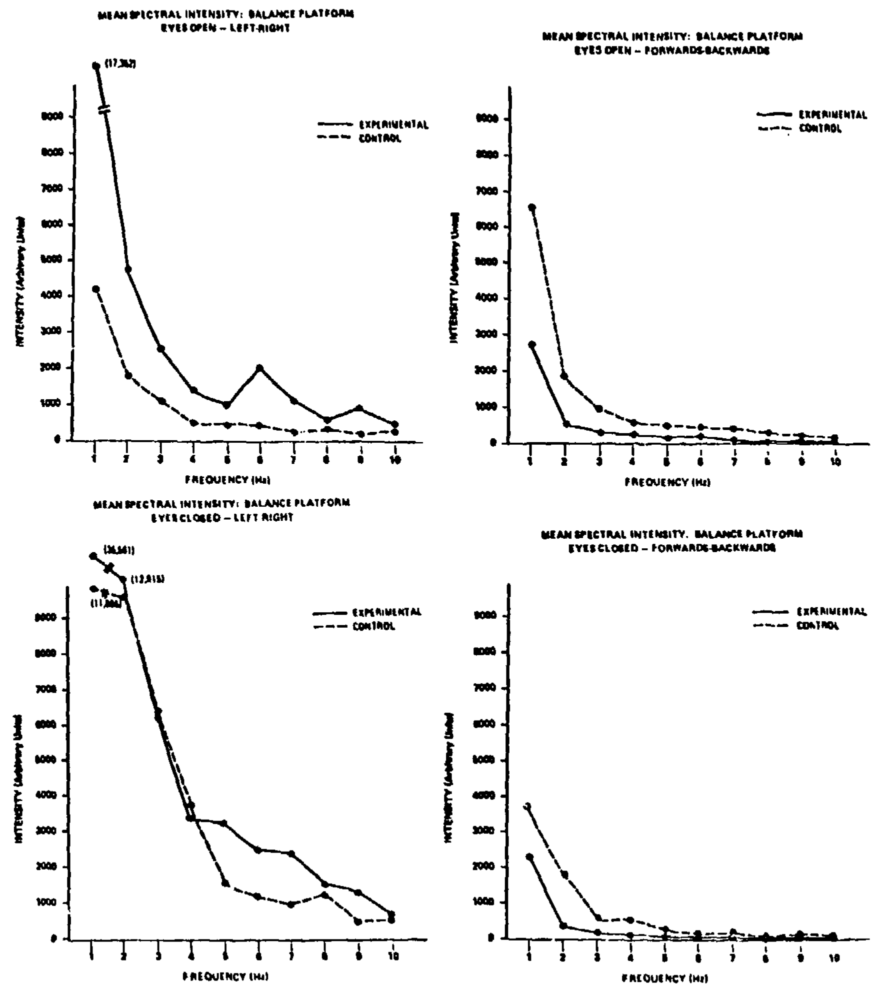


Fig. 4 Group mean spectra of balance platform data

at the lowest frequency. For the eyes open condition, the spectral intensity for the experimental group is lower in the forwards-backwards direction, but higher in the left-right direction. This seems to be generally true for the eyes closed condition as well. Stated another way, if one looks at the forwards-backwards direction, then for both eyes closed and eyes open conditions, the experimental group shows less spectral intensity than the control group, for both eyes open and eyes closed conditions. An analysis of variance was completed on these data and is given in Table VI. There was a significant group difference for the eyes open left-right condition. Other comparisons were nonsignificant.

TABLE VI. ANOVAs FOR THE BALANCE PLATFORM TASK

		EYES OPEN		EYES CLOSED	
X	F_A	1.02	>.05	1.67	>.05
	F_B	2.78	>.05	9.29	<.05
	F_{AxB}	0.36	>.05	0.76	>.05
Y	F_A	3.47	>.05	0.73	>.05
	F_B	12.12	<.05	23.35	<.05
	F_{AxB}	18.90	<.05	4.66	<.05

X = Forward-backward movement
Y = Left-right movement
A = Control vs. experimental group dF = 1, 24
B = Spectral intensities (1-10 Hz) dF = 9, 216
AxB = Interaction dF = 9, 216

Nystagmus: The data reduction process for this variable was to have been a computerized evaluation of the fast and slow components of nystagmus. However, a recently published report (Yee, et al., 1978) used such an analysis technique to compare normal subjects with patients with peripheral vestibular dysfunction. Their results suggested that the one proposed is not cost effective at this time. Yee, et al. used amplitude, duration, and velocity of the slow and fast components of each nystagmus cycle, but were unable to distinguish normals from the patients with unilateral vestibular damage. In view of this, a detailed computerized analysis of OKN was not undertaken in the present study,

DISCUSSION

The results of this study indicated little, if any, acute effects of intense noise on the variables measured. The rationale for selecting these variables was based on consideration of several things. First, the literature on noise effects suggests that physical symptoms and subjective mood would be negative in a high noise environment. Yet a comparison of the noise group with the control group on the Physical Symptoms Inventory showed no overall difference. Even consideration of preselected scales, based on expectations having particularly to do with noisy environments, also showed no difference between groups. One might speculate that the Wahler Physical Symptoms scale lacks validity, and that symptoms are not truly reported for the sake of maintaining job security, etc. Yet taken as part of the overall picture, there seems to be little reason to suppose that perceived illness exists irrespective of the lack of evidence for physiological effects.

With respect to the Profile of Mood Scale, a similar argument might be made. There is at this time no reason to suspect that subjective mood is any different among workers in high intensity noise environments. The observation that vigor appears to be unusually high among high noise workers is probably not important, since closer examination of the distribution of scores shows a high positive skew, indicating that one or two individuals, but not the average subject, in this group tended to score unusually high on this scale.

With respect to the physiological measures, they were chosen because they are indicators of vestibular and vestibulo-ocular function. The seven major peaks on the BAER are generally recobnized as representing neural activity in specific brain stem nuclei in the auditory channel. The work by Cazals (1980), for example, was taken as justification for including the BAER as a measure of possible vestibular system dysfunction as well as the more apparent auditory function. The averaged, within-groups BAERs were shown to be the same for the high noise and normal environments, thus mitigating the implication that damage occurred to auditory or vestibular primary receptors or to the major brain stem nuclei serving these sensory inputs.

The choice of cross correlation functions to reduce the electro-ocular eye tracking data was based partly on its widespread use in other sciences for measuring similar kinds of signals. When the sinusoidal waveform is sufficiently simple, in terms of the number of contributing sources, then the cross-correlation function yields two simple parameters of the relationship between input (eye-tracking stimulus) and output (electro-oculogram). The phase angle is the first parameter and is obtained by measuring the number of milliseconds from the "0" point on the correlogram to the point of the first maxima on the correlation function. This value can be translated into units of radians or degrees, if desired, since the frequency is known. For the purpose of testing an hypothesis about group differences, the translation is unnecessary and in this case was not done. Since the Hotelling T^2 analysis of the correlograms showed no significant group effect, it is concluded that lag in eye tracking is not adversely affected by prior exposure to intense noise. The same is true for the other parameter of this variable, correlogram amplitude. In this case the amplitude is a reflection of the "chatter" between input and output. The maxima was therefore taken as the dependent variable and showed no difference between groups.

The output of the balance platform gave some mixed results which probably merit some discussion. The Fourier Analysis provided a spectrum of intensity of body sway as a function of frequency. The discrete spectral components (one at each discrete frequency from 1 to 10) were then compared between groups by repeated measures analysis of variance. A significant difference appeared for the left-right body movement under the eyes open condition. At this point we can only admit that within the confines of this experimental procedure, the significant effect could be due to a real vestibulo-ocular dysfunction, or it could be generated by 2 or 3 individuals who chose to exaggerate their body movements, possibly as an expression of job dissatisfaction. However, the following consideration leads us to believe that the latter is probably the case: During the eyes closed condition, there is no significant difference between groups. If vestibulo-ocular dysfunction did in fact exist in the noise group, then by reducing further the peripheral cues (visual in this case), body sway decreases (at least as a group function) from the eyes-open condition to the eyes closed condition can only suggest that something other than vestibulo-ocular function is causing the significant F ratio to appear for this variable.

On the basis of these considerations, and within the confines that necessarily exist in a field study of this nature, it is concluded that no evidence exists for acute physiological, behavioral or subjective changes that can be attributed to intense noise jobs at Naval air stations.

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Physiological, behavioral and subjective data were obtained from 14 ground crew considered possibly to be at risk for nonauditory effects of intense noise while working around jet aircraft. Fourteen matched control subjects, working in normal noise environments were given the same test protocol. Brain stem evoked potentials, eye tracking behavior, balance, and nystagmus were compared between the groups and found to be nondiscriminating. In addition, subjective mood and perceived illness were compared and found to be the

20. Abstract (continued)

same in the two groups.

It was concluded that ground crew wearing the required ear protection devices do not show nonauditory effects of intense noise encountered on their jobs, and that within the confines of the variables studied, no evidence exists that current safety measures and standards are inadequate.

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